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Studying Farm Insurance Demand under Financial Constraints

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Abstract

We hypothesize a reciprocal causation between crop insurance use and the economic performance of farms in an environment characterized by imperfect financial markets and farms' budget constraints. To test our hypothesis, we apply a system of simultaneous equations consisting of economic performance and insurance demand models to the case study of Hungarian cropping farms. In addition, considering that insured farms may have better access to external finance, we seek empirical evidence confirming a potential positive effect of crop insurance on the economic performance of financially constrained farms. Our study results indeed confirm the reciprocal causation hypothesis.

Keywords: crop insurance demand; farm productivity; financial constraints; farm investment; Hungarian agriculture.

JEL: G22, L25, Q12, Q14.

Mezőgazdasági üzemek biztosítási keresletének vizsgálata pénzügyi korlát esetén

Baráth Lajos - Raushan Bokusheva - Fertő Imre

Összefoglaló

A cikkben reciprok kapcsolatot feltételezünk a biztosítás és a gazdaságok üzemi teljesítménye között egy olyan környezetben, amelyben a pénzügyi piacok működése nem tökéletes és jellemzőek a pénzügyi korlátok. A hipotézis teszteléséhez olyan szimultán egyenletrendszert használunk, amely a gazdasági teljesítmény és biztosítási kereslet közötti kapcsolatot modellezi a magyar növénytermesztő üzemek esetében. Mivel a biztosítással rendelkező üzemek könnyebben hozzáférhetnek külső finanszírozási formákhoz, az ebből adódó potenciális hatást is vizsgáljuk. Az eredmények egyértelműen alátámasztották a biztosítás és a gazdasági teljesítmény közötti reciprok kapcsolat meglétét.

Tárgyszavak: biztosítási kereslet; termelékenység, TFP, pénzügyi korlát, magyar mezőgazdaság, beruházás.

JEL: G22, L25, Q12, Q14

Agricultural production is affected by many sources of risk, including natural disasters. To ensure a stable economic performance, risks have to be efficiently managed. For extreme weather events such as flooding, hail or drought, on-farm risk management measures may be too costly and only partially effective. These risks in general could be much more effectively managed by financial risk management instruments such as crop insurance (Skees, 1999; Meuwissen, 2001).

Two aspects explain the farmer's use of crop insurance. The first one concerns the behaviour of the risk-averse decision maker. According to the Expected Utility (EU) model, the risk-averse decision maker is anticipated to be willing to pay the risk premium which is equal to the difference between her expected income and certainty equivalent. Therefore, in the case of crop insurance, the farmer pays to the insurer an insurance premium consisting of two parts – fair premium and risk premium. The second aspect considers positive externalities related to the stabilizing effect of crop insurance on the farm income (Hazell, 1985). This aspect might be especially relevant in the context of financial market imperfections such as credit rationing. In credit-rationed agricultural environments, as often found in developing and transition countries, farms with more stable incomes may obtain better access to credits and thus invest in more productive technologies. As the boost in production technology should lead to a significant increase in productivity, crop insurance use might indirectly lead to an increase in farm economic performance in the long term.

The first aspect of the farmer's use of crop insurance is present mostly under all circumstances. In this case, crop insurance premium reduces the risk-averse farmer's profit. The manifestation of the second aspect, however, is subject to a variety of factors related to both insurance product peculiarities and contract characteristics, and farm production and management specifics. Depending on the extent of both effects, the overall impact of crop insurance use on farms' long-term economic performance might be positive or negative. This study aims to conduct an empirical evaluation of the impact of crop insurance on the economic performance of farms. While several studies have investigated the demand for crop insurance, to the best of our knowledge, no study has evaluated the effect of crop insurance use on farm economic performance.

Empirical studies that assess determinants of economic performance (*e.g.*, Purdi *et al.*, 1997; El-Osta, 1998; Mishra *et al.*, 1999; Gloy *et al.*, 2002; Rizov and Mathijs, 2003; Gorton and Davidova, 2004; El-Osta *et al.*, 2007) use various methods such as Jovanovic's model of firm growth (Jovanovic, 1982) or a system of equations including a separate equation to appropriately model the effect of risk (Purdi *et al.*, 1997). These studies identify factors (*e.g.*, farm and farmer characteristics, production structures) which contribute to a farm's economic success. Studies on insurance demand mostly focus on discrete insurance choice models (Coble *et al.*, 1996; Mishra and El-Osta, 2002; Mishra and Goodwin, 2003; Enjolras and Sentis, 2008) and truncated models determining willingness to pay or coverage-level decision (Smith and Baquet, 1996; van Asseldonk *et al.*, 2002; Adhikari *et al.*, 2010). Most of the above-cited studies analyze farm insurance demand in the context of developed countries, where insurance demand is not necessarily affected by farmers' budget constraints. Regarding transition countries, however, farmers' budget constraints might seriously deter the use of crop insurance (Bielza Diaz-Caneja *et al.*, 2008). Under these circumstances, the farm's financial performance becomes an important determinant for the farmer's decision to purchase insurance. When formulating an insurance demand model, the neglect of this fact might cause endogeneity problems. Therefore, in our analysis we suggest using a simultaneous equation model which allows controlling for a reciprocal causation between farm insurance demand and economic performance.

This paper is organized as follows: the next section presents the methodology applied to cope with the problem of potential reciprocal causation between farms' economic performance and insurance demand. Because insurance demand is measured as the insurance premium paid, our estimation procedure has to involve a tobit model specification. Ordinary simultaneous least squares procedures would fail to provide consistent estimates under these conditions (Maddala, 1983). The third section discusses the empirical background of the study and presents the data. The empirical procedures employed are described in the fourth section. The specifications of the reciprocal causation model applied in the study are given in the fifth section. The sixth section presents and discusses estimation results. Finally, conclusions are drawn in the last section.

2. Methodology

In our study we employ a system of simultaneous equations formulated as follows (Amemiya,1979; Maddala, 1983):[1]

$$\left| \begin{array}{l} y_{1i} = \gamma_1 y_{2i}^{*} + \beta_{1j} X_{1ji} + u_{1i} \quad (1) \\ y_{2i}^{*} = \gamma_2 y_{1i} + \beta_{2j} X_{2ji} + u_{2i,} \quad (2) \end{array} \right|$$

where $i = 1, \ldots, N$ is the index of the farmer, and $j = 1, \ldots, M$ denotes the index of explanatory variables. The indices i and j will be dropped from now on for better legibility.

[1]The model notation is consistent with that used by Amemiya (1979) and Maddala (1983).

Equation (1) corresponds with the economic performance model. Accordingly, the dependent variable y_1 indicates the economic performance indicator and is observed, thus, $y_1 = y_1^*$.

Equation (2) describes the crop insurance demand model. In this equation, the dependent variable is a latent variable indicating the farmer's willingness to pay for crop insurance; accordingly, only positive values can be observed: $y_2 = y_2^*$ if $y_2 > 0$; otherwise, $y_2 = 0$.

The vectors of explanatory variables in (1) and (2) are denoted by X_1 and X_2, respectively. The variables u_1 and u_2 are the error terms of (1) and (2).

Coefficients γ_1, γ_2, β_{1i} and β_{2i} are parameters to be estimated. Coefficients γ_1 and γ_2 are expected to be non-zero and to obtain statistically significant estimates, which would confirm the hypothesis of reciprocal causation.

The model estimation algorithm follows the two-stage approach proposed by Nelson and Olson (1978), Amemiya (1979) and Maddala (1983). In the first stage, a reduced form model is estimated. The reduced form of the model (Maddala, 1983, model 2, p. 243) is

$$y_1 = \Pi_1 X + v_1 \quad (3)$$
$$y_2^* = \Pi_2 X + v_2 \quad (4)$$

where X consists of distinct column vectors in X_1 and X_2, Π_1 and Π_2 are the coefficients, and v_1 and v_2 are the error terms of the reduced model. The coefficients of the equation with the continuous dependent variable (equation 3) are estimated by ordinary least squares (OLS); those of equation (4) with the truncated dependent variable specification by the tobit method (Amemiya, 1979; Maddala, 1983).

In the second stage, the predicted values $\hat{y}_1 = \hat{\Pi}_1 X$ and $\hat{y}_2 = \hat{\Pi}_2 X$ from the first stage are used to estimate the following structural equations:

$$y_1 = \gamma_1 \hat{y}_2 + \beta_1 X_1 + u_1 \quad (5)$$
$$y_2^* = \gamma_2 \hat{y}_1 + \beta_2 X_2 + u_{2.} \quad (6)$$

Again, equation (5) is estimated by OLS, and equation (6) by the tobit model. This procedure leads to efficient estimates for coefficients γ_1, γ_2, β_1 and β_2. However, the standard errors of the second stage estimation are biased due to the use of estimated values for $\hat{y}_1$ and $\hat{y}_2$. Therefore, the correct asymptotic variance-covariance matrix is obtained according to the error correction procedure as formulated by Amemiya (1979).

3. Empirical Background and Data

The empirical analysis is done by employing the Hungarian crop farm data which were available from the national farm accountancy data network (FADN). According to the FADN, only about 40% of all Hungarian farmers who specialized in crop production used crop insurance products in the period from 2004 to 2009.

According to a survey conducted recently by the Hungarian Research Institute of Agricultural Economics (Kemény et al., 2011), the main reason for crop insurance purchase is risk management (as indicated by about 50% of the interviewed farmers). Roughly 20% of the interviewees answered that they purchase crop insurance mainly because it is demanded by an integrator. Furthermore, over 40% of the surveyed farmers responded that they do not have enough financial means to acquire crop insurance. The latter survey outcome is consistent with the findings by Bielza Diaz-Caneja et al. (2008) that the income situation of most Hungarian farmers does not allow them to cover the insurance cost, and that insurance products are mostly purchased because it is a requirement for getting loans.

The demand for crop insurance in Hungary might have been additionally limited because crop insurance available during the study period, i.e., from 2004 to 2009, did not provide coverage against the most important risks, such as drought or spring frost. However, since 2007 the Hungarian government has provided an alternative instrument for farm income stabilization, the so-called Damage Mitigation System (DMS), which covers such risks as drought and spring frost (Kemény, 2011). The DMS premium is financed 50% by participating farmers and 50% by the Hungarian government. In 2009, the DMS became mandatory for small- and medium-sized farms.

Additionally, a new insurance system – the New Risk Management Act (NRMA) – which aims to include all important risks, was launched in 2012. Under this NRMA, crop insurance and the DMS are combined to provide coverage against all important risks in Hungarian agriculture. In the NRMA framework, insurance premiums are expected to be subsidized up to 65% (Hungarian Chamber of Agriculture 2013). However, as the data for 2012 were not available, that year is not included in our analysis.

In our study we analyze the data for the period from 2004 to 2009. Although the FADN data were available for earlier periods, we intentionally exclude them from the analysis to focus on the period without any direct governmental support for crop insurance in Hungary[2] (Bielza Diaz-Caneja, 2008).

The analysis is conducted only for farms that specialized in crop production, as defined in the EU FADN (EU 2007). After deletion of observations with missing values, the total number of entries is reduced from 6571 to 4693.[3]

Table 1 presents the list of all variables considered in the analysis. Their descriptions correspond with the definitions of variables used in the EU FADN (EU 2007) and the Hungarian farm return form for farm reporting (AKI 2009a). Monetary indicators are given in 1000 Hungarian Forints (HUF), and are deflated to the year 2005 by using price indices as provided by the Eurostat and the Hungarian Central Statistical Office. Specifically, we use the agricultural output index to deflate the farm's total output. Variable inputs for crop production, total fixed assets and investments are deflated by employing the price index for purchased goods and services.

The crop insurance use is measured as the insurance premium paid per hectare of the farm's total agricultural land. Farm performance is characterized by two alternative measures – farm profit margin (PM) and total factor productivity (TFP) levels. The PM is defined as the ratio of the profit to the total output of a farm, and thus it is a measure of profitability. In our analysis, we define profit as the difference between total output and total input (Table 1). The derivation of TFP scores requires more explanations and will be described further in the text.

For purposes of the TFP estimation, the farm output variable is measured by the sum of sales and the value of agricultural products consumed at the farm. Land is defined as the farm's total agricultural area. Labour is measured as the number of annual work units, the capital variable is represented by the value of the farm's total fixed assets, and the materials variable is defined as total specific costs.

Other indicators used in the study are costs of irrigation, seeds, fertilizer and crop protection, and share of rented land. The extent of farm diversification is determined as the inverse of the Herfindahl index (Rhoades 1993), *i.e.*, the inverse of the sum of squared shares of outputs of different crops.

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[2]The practice of governmental subsidization of crop insurance premium was abolished in 2004. Accordingly, during the analyzed period (2004-2009), the Hungarian crop insurance market was functioning without substantial disturbances from the side of the government.

[3]Since corporate farms only voluntarily reported the educational levels of farm managers before 2009, missing values are filled up according to the data for 2009 and 2010 if the farms had been in the sample in earlier years (i.e., we assume that no major personnel changes in the farm management took place during those two years).

Table 1.

Summary statisticsa

Variable	Description	Mean	St. Dev.
Total input	Total production costs	22430.13	46122.36
Total output	Sales and farm internal use of agricultural products	19233.93	27870.36
Crop insurance	Insurance intensity: crop insurance premium paid per ha	0.65	2.46
Labour	Annual work units, full-time person equivalent	2.16	4.12
Land	Total utilized agricultural area	145.24	225.53
Materials	Total variable cost of production	7874.01	15403.54
Fixed assets	Value of farm fixed assets	44298.83	58046.74
Subsidies	Total subsidies, excluding subsidies on investments	7610.35	15912.03
Irrigation	Share of irrigated land	0.02	0.10
Seeds	Cost of seeds per 1 ha of land	16.85	29.60
Fertilizer	Cost of fertilizer per 1 ha of land	17.90	13.53
Crop protection	Cost of crop protection per 1 ha of land	13.07	12.55
Soil quality	Soil fertility measured in golden crown value[b]	20.53	7.10
Yield of wheat	Yield of wheat and spelt in t/ha	3.56	2.07
Yield of grain maize	Yield of grain maize in t/ha	5.29	3.59
Diversification	Inverse of sum of squared shares of output of cereals, protein crops, energy crops, potatoes, oil crops, sugar beets, industrial crops, vegetables and flowers, fruits, forage crops and livestock	1.91	0.62
Investment	Investment per 1 ha of land	30.13	94.57
Investment subsidies	Total subsidies related to farm investment	678.46	3694.56
Long- and medium-term loans	Loans obtained for a period of more than one year	0.71	0.46
Debts to assets	Total assets / Total liabilities	65.42	527.84
Rented land	Rented utilized agricultural area/total utilized agricultural area	0.44	0.34
DMS payments	Payments received from the DMS system	34.46	483.52
Age	Age of farm manager (years)	49.84	9.54
Education	Level of (agricultural) competence of farm manager: 1=none, 2=vocational studies underway, 3=skilled worker or technician, 4=farm engineer, 5=agricultural engineer	2.90	1.43

[a] Monetary values are given in 1000 HUF. The descriptions follow the definitions of variables used in the FADN and the Hungarian farm return form (AKI, 2009a).

[b] The average golden crown value indicates soil fertility, on the basis of the ancient currency “gold crown” of the Austro-Hungarian Monarchy (Burger 1998).

Source: FADN data and authors calculations

In addition to the continuous variables presented in Table 1, several dummy variables are created to control for regional and structural differences among the study farms. We distinguish among three different regions to control for agro-climatic differences. The largest share of analyzed farms (43.92%) is situated in the Great Plain. Transdanubia is represented in the sample by 38.1% of total observations. The remaining subset of farms (18.0%) is located in Northern and Central Hungary.

To account for the dichotomy present in Hungarian agriculture (Rizov, 2003; AKI 2009), we introduce a dummy variable for small, private family farms which form 49.6% of all sample observations.[4]

Furthermore, we distinguish between two periods: The first period consists of the years from 2004 to 2007, when there was no DMS, and the second period spans the years from 2007 to 2009, when the DMS was available. An additional dummy is created for 2009, indicating the year where the DMS became compulsory for small- and medium-sized farms.

4. Empirical Procedures

We introduce several adjustments to the data presented in the previous section to make it appropriate for the estimation of the simultaneous equation model. In particular, we use factor analysis to reveal latent structures in the data and derive the TFP levels, which in addition to farm PM, is used to quantify farm performance.

FACTOR ANALYSIS

The FADN data contain a large variety of variables (Table 1), each describing a particular aspect of the farm organization and management. If all variables are introduced into the analysis, multicollinearity problems could occur and cause biased estimates. At the same time, if the set of available variables is reduced to their selection, there is a danger of losing some valuable information. In our study, we cope with this problem by means of exploratory factor analysis.

The factors are generated using principle component analysis and Varimax rotation (Harman, 1976). To obtain a solution that reveals a latent structure within the data, we examine different sets of available indicators. Finally, a 10-factor solution is adopted for

[4] Family farms are determined as farms with a share of unpaid labor (full-time worker equivalent) higher than 95% (Hill 1993).

further analysis (Table 2). The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.79, which confirms the adequacy of this solution (Dziuban and Shirkey 1974).

Table 2.

Factor analysis results

Variable	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Labour	0.88[a]									
Land	0.94									
Fixed assets	0.80									
Subsidies	0.93									
Irrigation		0.75								
Seeds		0.80								
Fertilizer		0.65								
Crop protection		0.83								
Soil quality			0.66							
Yield of wheat			0.70							
Yield of grain maize			0.65							
Investment				0.83						
Subsidies on investment	0.41			0.62						
Long-, medium-term loans				0.32	-0.58					
Debts to assets					0.88					
Diversification						0.96				
Age							0.93			
Rented land								0.89		
Education									0.97	
DMS payments										0.96
SS loadings[b]	3.50	2.43	1.64	1.32	1.16	1.05	1.05	1.04	1.00	0.98
Proportion variance	0.18	0.12	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05

[a] Factor loadings of variables on 10 different factors (only loadings with an absolute value larger than 0.4 are reported).
[b] Sum of squares of loadings
Source: authors' calculations

The factors obtained are interpreted as follows: F1=farm size,[5] since the first factor is mainly determined by variables such as labour, land, fixed assets and subsidies, i.e., variables which capture different characteristics of the farm size. The second factor, F2=intensity, is formed by the intensity of the different inputs' use, in particular, irrigation, seeds, fertilizer and crop protection. The third factor, F3=production potential, is mainly determined by the soil quality and the yields of wheat and maize grain, i.e., it presents the farm's production

[5] In the text, factor names are written in italics.

potential. The fourth factor, F4=investment, refers to all variables related to investment, such as the investment intensity, subsidies on investment, and the long- and medium-term loans. The factor F5=indebtedness is primarily determined by the variable “debts to assets ratio” and is a bipolar factor, showing that highly indebted farmers are less likely to receive long- and medium-term loans. The remaining factors F6-F10 correspond to the single variables *diversification*, *age*, *rented land*, *education* and *DMS payments,* respectively.

TFP ESTIMATION

Out of the large variety of possible economic performance indicators, we use two indicators. The first indicator is the profit margin (PM). The second indicator is total factor productivity (TFP) level, which presents a more complex measure of farm performance. It expresses farm productivity as a ratio of all farm outputs produced to the total amount of inputs used for their production. Accordingly, while PM refers to the farm’s financial performance, TFP is more strongly related to production and technological aspects.

The TFP is a comprehensive measure summarizing technical efficiency change, technical change and scale efficiency change. Productivity can generally be estimated either by using direct index-number techniques based on price data, or by employing nonparametric or parametric techniques (Kumbhakar and Lovell 2003; Fried et al., 2008). Two latter approaches require the estimation of production technology parameters by employing a deterministic and nonparametric method called Data Envelopment Analysis (DEA) or a parametric method called Stochastic Frontier Analysis (SFA).

The DEA approach is more flexible as it does not require any assumption about the functional form of the frontier and any assumptions concerning the distribution of the inefficiency and stochastic noise terms (Fried, 2008). However, it is very sensitive to outliers. As stochastic specification of the production frontier permits taking into account random shocks that affect production but lie outside the producer’s control, SFA is considered a more appropriate approach for an environment characterized by considerable random shocks. Considering that our study is done for a transition country, we suppose that random shocks might indeed be pronounced in the data; thus, we employ the SFA approach. Additionally, to account for unmeasured heterogeneity, we use a Random Parameter Model (RPM) (Greene, 2005) defined for balanced panel data with $i = 1, \ldots, N$ indicating the farmers and $t = 1, \ldots, T$ indicating the time period.

A random parameter model (Greene, 2004) is generally formulated as follows:

$$y_{it} = \alpha_i + \mathbf{x}'_{it}\boldsymbol{\beta}_i + v_{it} - u_{it}, \qquad (7)$$

with

$$\begin{pmatrix}\alpha_i\\ \beta_i\end{pmatrix} = \begin{pmatrix}\alpha\\ \beta\end{pmatrix} + \begin{pmatrix}\Delta_\alpha\\ \Delta_\beta\end{pmatrix}\mathbf{h}_i + \begin{pmatrix}\omega_{i\alpha}\\ \omega_{i\beta}\end{pmatrix}$$

$$v_{it} \sim N[0, \sigma_v^2],\ u_{it} = |U_{it}| \text{ and } U_{it} \sim N[\mu_i, \sigma_u^2],$$

$$\mu_i = \mu + \mathbf{h}'_i\delta_i,$$

$$\delta_i = \delta + \Delta_\delta \mathbf{h}_i + \omega_{i\delta} \text{ and}$$

$$\omega_i = (\omega_{i\alpha}, \boldsymbol{\omega}'_{i\beta}, \boldsymbol{\omega}'_{i\delta}) \sim N[\mathbf{0}, \boldsymbol{\Omega}],$$

where y_{it} denotes the log of the output, $\mathbf{x}_{it}$ is the log of the inputs, $\mathbf{h_i}$ represents unmeasured heterogeneity, v_{it} is the stochastic noise term and u_{it} is the inefficiency term.

We use the translog functional form to specify our empirical model, *i.e.*:

$$\begin{aligned}\ln y_{it} = {} & \beta_0 + \sum_{k=1}^{K}\beta_k \ln x_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K}\beta_{kl}\ln x_{kit}\ln x_{lit} + \beta_t t \\ & + \frac{1}{2}\beta_{tt}t^2 + \sum_{k=1}^{K}\beta_{kt}\ln x_{kit} t + v_{it} - u_{it}.\end{aligned} \qquad (8)$$

We define the output y as the farm's total output (see Table 1), and use four inputs ($k = 1, \ldots, 4$), namely, labor (x_1), land (x_2), capital (x_3) and materials (x_4). Additionally, a time variable t is added to capture the effect of technological change.

For purposes of the TFP calculation, we use a transitive multilateral consistent TFP index, following the approach proposed by Caves et al. (1982) 6. The TFP index constructed in this way allows both multitemporal (i.e., two points in time) and multilateral (i.e., two farms at a similar point in time) comparisons7. The basic idea of Caves' approach is to consider deviations from the sample means in the construction of the index. Accordingly, in general, the translog multilateral productivity index between farm i in period t and the sample average can be formulated as follows:

[6]To calculate this index, we have to reduce our sample to a balanced data set, which results in 4020 entries.

[7] Further information about the background and empirical usage of this method can be found e.g. in Timmer et al. (2010).

$$\ln TFP_{it}^{*} = \frac{1}{2}\sum_{m}(r_{mit} + \overline{r_m})(\ln y_{mit} - \overline{\ln y_m}) - \frac{1}{2}\sum_{k}(w_{kit} + \overline{w_k})(\ln x_{kit} - \overline{\ln x_k}), \quad (9)$$

with $m = 1, \ldots, M$ outputs and $k = 1, \ldots, K$ inputs; r and w stand for single outputs' and inputs' shares, respectively. The bar above a variable refers to the arithmetic mean of the variable over all sample observations.

In addition, instead of using inputs' and outputs' shares, the TFP index can be constructed using the production technology parameter estimates. Two main advantages of this approach are: first, the index can be calculated without price data; second, it allows TFP change decomposition due to different sources.

In particular, the TFP index can be decomposed8 into: an effect which results from adjustments in the scale of factor use (SEC), technological change effect (TCH) and technical efficiency change (TEC), i.e.:

$$TFP = SEC + TCH + TEC. \quad (10)$$

Table 3 presents model parameter estimates (see Appendix). As the input variables are normalized by their geometric means, the first order coefficients correspond to the output elasticities evaluated at the sample mean. The model parameter estimates show that all output elasticities have expected signs and are significantly different from zero. Moreover, the estimates of the time variable t imply that a technological regress occurred over the analyzed period. The sum of elasticities was 1.06, which suggests slightly increasing returns to scale. The estimate of the lambda parameter was 2.4 and was statistically significant, indicating that inefficiency is an important phenomenon in Hungarian agriculture; consequently, omitting the inefficiency term from the production model would have caused biased results.

Since theoretical conditions–monotonicity and necessary conditions for quasi-concavity–were fulfilled in the model, we can state that its results are applicable for our empirical analysis.

[8]For the formal description of this separation, consult Caves (1982).

Table 3.

SFA model parameter estimates

Non-random parameters		Means for random parameters	
Parameter	Coefficient	Parameter	Coefficient
t^2	-0.002	Constant	0.276 ***
Labour*Land	-0.060 ***	t	-0.009 ***
Labour*Capital	0.000	Labour	0.144 ***
Labour*Materials	0.001	Land	0.387 ***
Land*Capital	-0.048 ***	Capital	0.103 ***
Land*Materials	-0.166 ***	Materials	0.429 ***
Capital*Materials	0.013		
Labour^2	0.108 ***	**Variance and asymmetry parameters**	
Land^2	0.231 ***	Sigma	0.441 ***
Capital^2	0.043 ***	Lambda	2.435 ***
Materials^2	0.137 ***		
t*Labour	0.001		
t*Land	-0.006		
t*Capital	0.000		
t*Materials	0.008		

Source: authors' calculations

5. Model Specifications

In our empirical analysis, we employ two model specifications, corresponding with two economic performance indicators employed. The first specification refers to PM, a simple financial measure of farm performance. Similar straightforward measures like net farm income or the income of a farm in relation to the income of other farm indicators are used in empirical studies by *e.g.*, El-Osta (1998), Mishra (1999), El-Osta *et al.* (2007) or Aggelopoulos *et al.* (2007). Some studies employ long-term indicators that measure the stability of farm performance. For example, Purdi *et al.* (1997) use both the mean and variance of return on equity over 20 years. However, our data set is not sufficiently long to obtain reliable estimates of the variance and higher moments of distribution.

The second model specification uses TFP level as the dependent variable in the economic performance model. While most empirical literature employs technical efficiency as an indicator of farm productivity (e.g., van Passel, 2006; Davidova and Latruffe, 2007; Hansson and Öhlmér, 2008; Bojnec and Latruffe, 2009; Bakucs et al., 2011), only a few studies apply TFP to describe farm performance in a modelling approach (e.g., Gardebroek, 2003).

However, since the TFP indicator is a more comprehensive measure of farms' productivity, it allows for a more complete assessment of farm performance.

Besides the two different economic performance indicators, other model parameters (the second dependent variable and all the explanatory variables) remain the same for both model specifications.

THE ECONOMIC PERFORMANCE MODEL

The set of the explanatory variables in the economic performance model consists of the factors *farm size*, *intensity*, *investment*, *production potential*, *diversification*, *rented land*, *age* and *education*, as well as dummy variables for single regions and family farms (the region of Central Hungary and non-family farms are used as the reference category), and the time variable. With our choice of explanatory variables, we are in line with many recent empirical studies conducted to identify determinants of income variation (El-Osta and Johnson, 1998; Mishra *et al.*, 1999; El-Osta *et al.*, 2007), farm long-term performance (Purdi *et al.*, 1997; Gloy *et al.*, 2002; Rizov and Mathijs, 2003), or farm technical efficiency (van Passel *et al.*, 2006; Davidova and Latruffe, 2007; Hansson and Öhlmér, 2008; Bojnec and Latruffe, 2009; Bakucs *et al.*, 2010; 2012).

Size-related variables reveal economies of scale effects and are thus considered by most above-cited authors (Purdi et al., 1997; Gloy et al., 2002; Rizov and Mathijs, 2003; van Passel et al., 2006; El-Osta et al., 2007).

The factors indicating the intensity of the production and farm production potential (factors 2 and 3, respectively) are expected to obtain a positive coefficient estimate. As investment in new, more productive technologies are supposed to improve farm productivity and long-term performance, the factor investment is expected to influence both economic performance measures positively.

Diversification refers to economies of scope; its impact might strongly depend on the peculiarities of the farm's external environment. Therefore, it is not surprising that this variable's effect differs from study to study. Purdi et al. (1997) reveal a negative impact of diversification on the mean of the economic performance indicator, but a positive impact on its variance. However, diversified farms tend to be less efficient in production, according to van Passel *et al.* (2006).

The effect of the farm manager's *age* (factor 7) on farm performance is difficult to predict *a priori*. On one hand, older managers might be more experienced and thus more successful in their business. On the other hand, younger managers might exhibit more entrepreneurial abilities than their older counterparts educated during the Socialist time, and thus have better prospects to increase farm performance. For example, Bakucs and Fertő (2009) show that the age of farmers has a negative impact on farm growth.

The share of *rented land* (factor 8) can be regarded as an indicator of farm growth and thus might signal farm entrepreneurial and managerial capacities. Accordingly, it is expected to have a positive effect on farm economic performance. A similar outcome should be triggered by the farm manager´s *educational background* (factor 9).

Several recent studies consider in their analyses the share of paid labour input (Gloy *et al.*, 2002; Davidova and Latruffe, 2007; Bojnec and Latruffe, 2009). In our study, we control for this aspect through the family farm dummy variable. However, the impact of this variable is difficult to predict. Although family farms have a negligible wage cost, economies of scale may overweigh this advantage.

THE INSURANCE DEMAND MODEL

In both model specifications, the crop insurance demand is measured as the insurance premium paid per hectare of farm agricultural land. Explanatory variables are the factors *size*, *investment*, *potential*, *DMS payments*, *diversification*, *rented land*, *age*, *education* and *indebtedness*, as well as the dummy variables for family farms, the 2007-2009 period and the year 2009 (non-family farms and the 2004-2006 period are the reference categories, respectively).

The objectives of previous empirical studies on determinants of insurance demand are: to find reasons for a low participation in agricultural insurance programs (van Asseldonk et al., 2002; Enjolras and Sentis, 2008), to detect moral hazards and adverse selection problems (Coble et al., 1996; Smith and Baquet, 1996), and to determine factors that could help improve policies and target supportive payments more precisely (Mishra and El-Osta, 2002; Mishra and Goodwin, 2003; Adhikari et al., 2010). Next to farm accountancy data, customized surveys and/or climate data are often included in such analyses (Coble et al., 1996; van Asseldonk et al., 2002; Sherrick et al., 2004; Morales et al., 2008).

Determinants of insurance demand employed in recent literature can be categorized into groups of variables indicating risk management substitutes, the farmer's risk perception and attitude, farm risk exposure and farm characteristics such as size, economic performance or investment.

In our study, risk management substitutes include *diversification* and *DMS payments*. The impact of risk management substitutes on crop insurance demand is expected to be negative. This effect is supposed to be particularly pronounced in the context of a credit-rationed agriculture. Indeed, we suppose that farmers experiencing budget constraints do not have enough means to adopt several risk management measures at the same time.

Furthermore, we employ the farmer's *age* and *education*, as well as farm *indebtedness*, as important determinants of the farmer's risk perception and attitude. Older and/or better educated farmers might perceive risk more adequately and be able to choose a more suitable risk management instrument for their farms. Most recent studies have found a positive impact of the farmer's education on insurance use (except Enjolras and Sentis, 2008). However, regarding the farmer's age, the results are inconsistent across different investigations; while Sherrick *et al.* (2004) reveal a positive impact of the farmer's age on insurance demand, Enjolras and Sentis (2008) find it to be negative. Additionally, Mishra and Goodwin (2003) and van Asseldonk *et al.* (2002) report no significant effect of the farmer's age on crop insurance demand.

Furthermore, considering Arrow's hypothesis of decreasing absolute risk aversion (DARA) (1971), wealthier farmers, who can be identified in our data by the farm size, are less risk averse and therefore less likely to purchase crop insurance. However, the authors who estimate a significant impact of farm size on insurance demand (Coble et al., 1996; Enjolras and Sentis, 2008), find it to be positive. Additionally, in the context of a transition economy, provision of financial services to large farms might be associated with lower transaction costs per unit of the insured acreage than for their smaller counterparts. Accordingly, potentially the use of crop insurance can be higher for larger farms in Hungary.

Farm indebtedness can also be used as an indicator of the farmer's risk attitude. On one hand, farmers with a higher level of the leverage might be regarded as less risk averse, since they are ready to accept a higher financial risk. In this case, the farmer should be less likely to purchase crop insurance.[9] On the other hand, burdens of financial obligations might make the farmer more risk averse. If the latter is true, a higher level of leverage would lead to a higher demand for insurance. Indeed, recent studies reveal a positive impact of this variable on the insurance demand (Smith and Baquet, 1996; Mishra and El-Osta, 2002; van Asseldonk et al., 2002; Mishra and Goodwin, 2003). This empirical finding suggests that in developed countries, the second phenomenon prevails, *i.e.*, higher indebted farms face a higher farm risk exposure and are therefore more likely to purchase insurance.

Another variable indicating the farm risk exposure is farm *production potential*, a factor including soil quality and yield of wheat and grain maize. A good and stable farm production

[9] A high indebtedness could also limit the crop insurance use because of more severe budget constraints of indebted farms.

potential can be found in regions facing less natural disasters and thus, a lower risk level. This variable's coefficient can therefore be expected to have a negative sign.

It is difficult to predict the sign of the coefficient for the dummy variable family farm. On one hand, family farmers might be more risk averse compared to corporate farms where several holders jointly own the farm. On the other hand, budget constraints might be more pronounced in the case of family farms.

The dummy for the 2007-2009 period, when the DMS was available for farmers (period 2), and the dummy for the year 2009, when the DMS became compulsory for small- and medium-sized farms, are both expected to have a negative impact on crop insurance demand, since the DMS can be considered as a crop insurance substitute.

Finally, only Enjolras and Sentis (2008) indicate a significant impact of the economic performance indicator on insurance demand. In their analysis, the effect is negative. However, since our case study lies in an institutional environment, with farmers evidently facing budget constraints, farm financial performance is expected to have a positive impact on the crop insurance demand of farms.

6. Results and Discussion

Table 4 shows the estimation results for the two model specifications employed in our study, as described in the previous section. The coefficient estimates of the economic performance model can be found on the table's left-hand side, while the estimates presented on the right-hand side refer to the crop insurance demand model.

RESULTS OF THE ECONOMIC PERFORMANCE MODEL

The coefficient of the crop insurance use in the economic performance model has a negative sign and is significant for both model specifications. Accordingly, farmers who use crop insurance show a significantly lower economic performance than non-users. It can be concluded that either there is no positive effect of crop insurance on farm performance, or its extent is relatively small to compensate for insurance premium cost. This implies that farmers who purchase crop insurance are risk averse and willing to accept a lower income to reduce their risks.

Table 4

System of equations' estimation results [a, b]

Economic Performance Model			**Crop Insurance Demand Model**		
	PM	TFP		PM	TFP
Insurance use	-0.07 **	-0.05 ***	Econ. performance	5.13 **	12.27 **
Intercept	153.90 ***	23.08 ***	Intercept	-1.67 ***	-0.84 ***
Farm size	-0.05 *	0.05 ***	*Farm size*	0.66 ***	-0.19
Intensity	0.03	0.01	*Investment*	0.81 ***	0.30 ***
Investment	-0.03 **	-0.001	*Prod. potential.*	0.30	-0.38
Prod. potential	0.12 ***	0.07 ***	*DMS payments*	0.25 *	0.08
Diversification	0.01	-0.001	*Diversification*	-0.30 **	-0.07
Rented land	-0.03	0.02 ***	*Rented land*	0.67 ***	0.01
Age	-0.03	-0.03 ***	*Age*	0.42 ***	0.33 **
Education	0.002	0.002	*Education*	0.16	0.24 ***
Transdanubia	-0.16 **	-0.02	*Indebtedness*	-0.58 ***	-0.21 ***
Great Plain	-0.06	0.003	Family farm	-0.72 ***	0.06
Family farm	0.03	-0.03 ***	Period 2	-0.36	-0.18
Year	-0.08 ***	-0.01 ***	Year 2009	4.48 ***	2.07 ***

[a]The results are presented according to the two different economic performance measures, profit margin (PM) and total factor productivity (TFP).
[b]The reported values are the estimated coefficients of every variable, *, ** and *** denote significance at the 10%, 5% and 1% level.
Source: authors' calculations

From production-related factors, only production potential obtained a significant positive effect on the farm profit. The effect of farm size on the profit is found to be negative at the 0.10 significance level. At the same time, the factor size yields a significantly positive coefficient estimate in the TFP specification. This result suggests the presence of economies of scale in Hungarian agriculture and is consistent with findings by Gorton and Davidova (2004). The opposite signs of the effect of size on two considered farm performance measures imply that when determining farm performance by productivity growth, which is a relative measure free of price effects, larger farms seem to be more successful than their smaller counterparts. However, when the performance is measured in terms of PM, smaller farms perform better. This is a very interesting empirical finding which evidently points at some differences in the behaviour of large- and small-scale farms in Hungary – while smaller farms appear to exhibit profit-maximizing behaviour, their larger counterparts seem to pursue revenue maximization.

Furthermore, our empirical results do not suggest the presence of economies of scope – the factor diversification does not obtain significant coefficient estimates in any specification. Neither does the factor investment gain a significant estimate in the TFP specification; however, it has a negative sign of the coefficient estimate in the PM specification. Considering that in a credit-constrained environment, farms finance their investment to a large part from their own profit, the latter result is quite reasonable.

Farms with higher shares of rented land perform better in terms of TFP. This result supports our hypothesis about higher entrepreneurial and managerial capacities in farms with higher shares of rented land. However, we are unable to reveal any significant effect of the farm manager's education on farm performance. While the farm manager's age does not significantly influence the farm profit, it has a negative effect on farm productivity. Accordingly, younger farmers in Hungary seem to be more keen and successful in their efforts to improve the long-term performance of their business, e.g., by investing in more productive technologies, than their older counterparts.

As for the regional dummy variables, our model estimates indicate that, compared to Central Hungary (captured by the intercept), Transdanubian farms have a lower PM, but the performance of the Great Plain farms does not differ significantly. Our estimation results also show that family farms have a significantly lower TFP. However, we are unable to find significant differences in the performance of two groups of farms considering PM. Finally, we observe a negative trend in both the PM and TFP developments. This finding is in line with empirical evidence which might go back to a negative trend in the development of Hungarian economy in the second half of the first decade of 2000s.

RESULTS OF THE CROP INSURANCE DEMAND MODEL

As for the crop insurance demand model, we find a positive effect of both PM and TFP level on the crop insurance demand. This result indicates that the economic performance of farms significantly influences Hungarian farmers' demand for crop insurance and points at the presence of farm budget constraints in Hungarian agriculture.

The effect of further factors is quite consistent across the two model specifications. Farm investment activity significantly increases the Hungarian farm's demand for crop insurance in both model specifications. This finding is reasonable, as farms with a higher level of investment are exposed to a greater degree of uncertainty concerning their future cash flow. A similar effect is present for farms with higher shares of rented land.

Furthermore, according to the PM specification, larger farms are more likely to purchase crop insurance. This result confirms our hypothesis about better access of large farms to financial services in the presence of high transaction costs in rural financial markets. This finding is also supported by a significantly negative estimate for the family farm dummy variable in the PM specification.

According to our estimation results, the DMS seems to be rather a complement than a substitute for crop insurance. This result is quite reasonable because the DMS has provided coverage against several hazards for which none has been offered by the Hungarian crop insurance system. Our estimates also indicate that lowering risk due to diversification can indeed be regarded as an on-farm substitute for crop insurance.

The significant negative coefficient of indebtedness emphasizes that less indebted farms are more likely to purchase crop insurance. This finding is logical, considering that farms with lower financial obligations have more free means to purchase crop insurance. Moreover, farmers who intentionally avoid borrowing might be more risk averse and thus more willing to purchase crop insurance, compared to their counterparts who more easily incur debts.

Age and education both have a positive impact on crop insurance demand. This suggests that better educated and more experienced farmers consider crop insurance as a valuable risk management tool.

7. Conclusions

We postulate a reciprocal causation between farm economic performance and crop insurance demand in the context of a transition economy. To test for this potential relationship between economic performance and insurance demand, we use the simultaneous equation model as formulated by Nelson and Olson (1978), Amemiya (1979) and Maddala (1983). Exploratory factor analysis serves to reduce the set of variables to a group of factors which are later used as the determinants in the simultaneous equation model. A further empirical procedure involves the derivation of a multilateral consistent TFP index proposed by Caves et al. (1982), using the estimated technological parameters of a random parameter model (Greene, 2004; 2005). Together with the farm PM, TFP scores are used as measures of farm economic performance in two alternative model specifications.

Based on this methodology, the study seeks empirical evidence for: (i) the presence of financial constraints in Hungarian agriculture, which makes farm economic performance an important determinant of farm insurance demand and (ii) the presence of a positive externality, which might be generated by crop insurance in a credit-rationed economic environment. In particular, we test whether the use of crop insurance by improving farmers' access to external finance allows the insured farmers to improve their economic performance through adoption of more productive technologies.

Our empirical results confirm our hypothesis of reciprocal causation between farm economic performance and insurance demand in the context of Hungarian agriculture. According to both model specifications employed, both measures of economic performance have a positive and significant impact on farm insurance demand.

Furthermore, the study's findings indicate that financial restrictions indeed constrain Hungarian farmers' demand for crop insurance, and are thus in line with Kemény et al.'s findings (2011). However, our estimation results suggest a negative impact of crop insurance use on the economic performance of Hungarian cropping farms. Even though this result contradicts our expectations about the insurance capacity for generating positive externalities, it agrees with the EU model, according to which the risk-averse farmer is ready to pay a premium to reduce her risk exposure.

Our model estimates show that further important determinants of the Hungarian farm performance are agri-climatic conditions, which we have captured with the factor production potential, as well as farm managers' entrepreneurial abilities leading to expansion of their farm's production possibilities by renting additional land. Moreover, our estimates suggest that while large farms in our sample are more productive in terms of scale and technical efficiency, their smaller counterparts seem to perform better regarding allocative efficiency. This situation might be related to a lower extent of agency problems and a more effective incentive structure within small entities.

The main determinants of the Hungarian farm crop insurance demand are farm investment and farm size. Indeed, our results suggest that larger and corporate farms seem to have better access to crop insurance. This finding again implies some imperfections in the Hungarian rural financial market, when financial institutions seek to reduce their transaction costs by offering their services to relatively large entities only. Finally, we could reveal different preferences of Hungarian farms regarding risk management strategies: farms involved in diversification – an on-farm management strategy – exhibit a significantly lower demand for crop insurance, whereas farm participation in the damage mitigation system – a risk-sharing strategy – increases farm demand for crop insurance. This finding can be explained either by varying perceptions and experiences of farmers with financial risk management instruments or by the nature and extent of their risk exposure. Indeed, certain risks can only be partially managed on the farm and have to be shared in a pool with others.

The long-term effect of crop insurance on farm performance is particularly relevant to the decision about governmental subsidization of agricultural insurance. Our study presents an attempt to evaluate the effectiveness of an agricultural insurance system in the context of a transition economy. Although we were unable to find any significant positive effect of crop insurance on farm performance in the Hungarian agriculture context, the methodology applied in our study can be used to evaluate insurance programmes in other transition or developing countries. Moreover, given the farm budget constraints, studies into crop insurance demand determinants might produce biased results if not controlling for the potential reciprocal causation between farm economic performance and insurance use.

Although this study employs a dataset for a quite representative period of six years, data for a longer period would be required to obtain more robust results and to study interactions among farm performance, investment and demand for crop insurance by employing a dynamic model specification. Moreover, future research should involve an analysis of the crop insurance effect on variance and higher moments of the farm income distribution.

Considering Hungary's case, the government has to initiate major efforts to improve the effectiveness of crop insurance products. The New Risk Management Act launched in 2012 is definitely a right step in this direction, with its aims to improve insurance effectiveness and address both farm budget constraints and the lack of trust issue. The design and implementation of insurance products that are better tailored to the farmers' needs and temporary governmental insurance premium subsidies to encourage insurance use may restore trust in the insurance system. An adequate time horizon for governmental subsidization should be chosen so that positive externalities of insurance use can become evident for farmers. The evaluation of this new system may generate important insights for further improvement of insurance products in other economies.

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